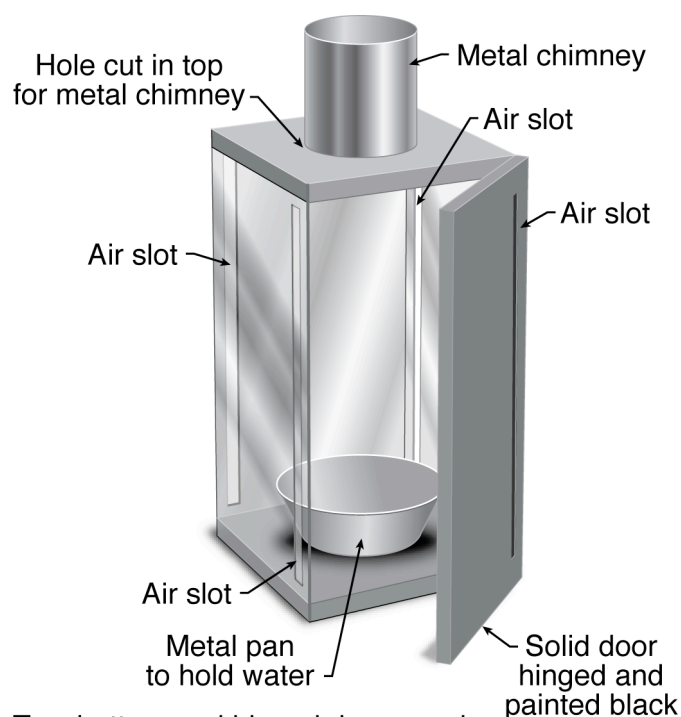




Chapter 13. Tornado In a Box (TIB) or Cyclone in a Box (CIB)

Introduction

The apparatus, called “Tornado In a Box” (TIB) or “Cyclone In a Box” (CIB), is useful for studying certain aspects of model low-pressure systems. Natural low-pressure systems exist in phenomena such as tornadoes, hurricanes, and large, low-pressure weather systems, such as cyclones. The interrelationships between low-pressure systems and attributes such as temperature, humidity, low pressure, and wind speed are extremely varied and are keys to understanding important aspects of weather and climate. With the TIB/CIB apparatus, students can investigate many of the interrelationships and changes within low-pressure systems. Inquiry learning can be reinforced using the TIB/CIB. Use of the TIB/CIB will facilitate understanding the design and use of the four levels of inquiry learning.



Top, bottom and hinged door wood
Three sides plexiglass for viewing

Figure 13-1. TIB/CIB.



Figure 13-2. Formation of a model low-pressure “cloud.”

The TIB/CIB shown in Figure 13-1 can provide the opportunity to actively examine a model low-pressure “cloud” formation to facilitate a better understanding of important interrelationships and dynamics of natural low-pressure systems. The formation of the model low-pressure “cloud” when the warm, rising air condenses to a liquid inside the TIB/CIB can be observed in figure 13-2. Instructions for constructing the TIB/CIB can be found in Appendix VI.

It should help to bring closure to the variety of activities discussed and conducted throughout this publication. Further, it should challenge the learner to design open-inquiry activities beginning with the establishment of a testable hypothesis, design the procedure, conduct the investigation, and draw an appropriate conclusion as dictated by the data generated. It is important to bring the learner to an early stage of open-inquiry design.



Is There a Relationship Between Surface Heating (Temperature) and the Formation of a Low-Pressure System? Confirmation and Verification (Teacher Centered) Activity

Think About This!

Have you ever observed a very small circulating pressure system (called a dust devil) moving across a flat dusty area or a littered parking lot, twirling dust or debris that defined it and its movement? If so, what time of day and time of year was it observed? How long did it last? Did you notice anything in particular interfering with its duration or movement?



Probing Further

Investigate what causes these “dust devils” to form and move across the surface. Because of the small size, unpredictable appearances and the rapid movement of these systems, it is very difficult to study them in action. Because they are really small moving low-pressure systems, the TIB/CIB might provide some insight into this phenomenon.

For the Teacher

Instruct the students that they will observe the formation and dissipation of a model low-pressure “cloud” by completing the following activity. Provide students with access to the materials described below. Caution students about safety procedures for handling the burner and hot water. Make sure they are wearing the safety goggles and heat-resistant gloves.

Objectives for the Learner

Conceptual Theme: To develop a basic understanding of interrelationship between heat (indicated by temperature) and a model low-pressure system defined by the “cloud” formation and movement inside the TIB/CIB.

Content: Developing basic information about the formation of a model low-pressure “cloud.”

Skills: The focus is on observation, handling of laboratory equipment, and communicating the outcomes.

Scientific Habits of Mind: The importance of careful observations and the need to follow safety procedures.

Procedure

Caution the students about safety procedures for handling the burner and the hot water. Make sure that they are wearing the safety goggles and heat-resistant gloves.

1. Place the TIB/CIB device on a solid, flat surface and away from all books and other materials.
2. Open the door of the vortex device and center the metal container inside at the bottom. Place the hot plate on a solid surface near the TIB/CIB.
3. Put on your safety glasses and heat-resistant gloves.
4. Pour 500 milliliters (ml) of water in the heat-resistant beaker and place it on the hot plate. Turn on the hot plate and allow the water to come to a boil.

Materials

TIB/CIB device

Metal pan for bottom of TIB/CIB

500-ml heat-resistant beaker

500 milliliters of tap water

Beaker tongs for handling a hot beaker filled with water

Electric hot plate

Heat-protective gloves

Safety glasses



5. Once the water has come to a boil, use the beaker tongs and carefully lift the beaker and pour the hot water into the metal pan at the bottom of the TIB/CIB device. Quickly close the door and make careful observations of what happens inside the TIB/CIB until you can no longer see the rising “cloud.”

6. Turn off the hot plate and place the beaker on a heat resistant surface.

NOTE: This confirmation-verification activity can be made quantitative by conducting the activity four or five times. This approach provides data that can be averaged and graphed to illustrate outcomes.

Examining Results

The purpose of this activity is to help the learner to examine in a concrete way some of the interrelationships and changes that occur in a low-pressure system. With the TIB/CIB apparatus, students can investigate the interrelationships between

temperature (heat) and its role in the formation and duration of low-pressure systems.

How would you describe the changes that you observed inside the TIB/CIB apparatus?

When the hot water was poured into the metal pan and the door closed, there was probably steam (cloud) that formed inside the TIB/CIB. (After a few minutes, the steam began to spiral as cooler air flowed in to replace the rising warm air and moved toward the upper part of the box.) After a short time, the “cloud” became better defined and continued to contract the spiral. This likely continued until the water cooled below a certain temperature and the cloud disappeared. The slits in the TIB/CIB apparatus cause a spin in the air currents. In the case of a cyclone, this spin is caused by the Coriolis Effect. In the case of a tornado, this spin is thought to result from the development of a mesocyclone. In any case, the spin is provided by the placement of the slits.

Do you have any evidence that temperature had an effect on the formation and the duration of a low-pressure system? Explain.

The student might infer that the temperature had an effect on both the formation and duration of the low-pressure system (the spiraling cloud), but there is little or no valid evidence from just this activity. More activities can be conducted to produce such evidence.

How could you further verify the relationships between temperature and duration?

Conduct a series of experiments that vary the temperature. Time the duration of the spiraling cloud at the various temperatures and compare the results.

Conclusion

After conducting this activity, what major conclusion did you draw, regarding relationship between temperature and conditions for low-pressure system development as illustrated by cloud formation and its movement inside the TIB/CIB?

The activity helps to illustrate the important relationship between heat (indicated by temperature) and a model low-pressure system defined by the “cloud” formation and its spiral movement inside the TIB/CIB.

Going Further

How could you better validate the important inter-relationship between heat (temperature) and the formation of the TIB/CIB low-pressure phenomena?

Conduct a series of similar activities at varying water temperatures and time the duration of the model low-pressure system as defined by the formation and action of the cloud.

Challenge

Think of a series of other activities that you could perform to develop more evidence of the important interrelationships of heat and low-pressure system formation.

There is a variety of activities that could be performed such as comparing different amounts of water at the same temperature and compare the duration; comparing the same amount of water at different temperatures and compare the duration; comparing various liquids such as salt water, fresh water, and distilled water using same amounts and same temperatures and compare duration; and many others.

Background for the Teacher

The apparatus called “Tornado in a Box” or “Cyclone in a Box” in the figures here is often used to demonstrate and depict the formation of tornadoes. However, it can also be used to study the factors associated with cloud formation in low-pressure systems, such as cyclones or hurricanes. In the present context, the TIB/CIB device is used as a CIB model.



Is There A Relationship Between Surface Heating and the Formation and Duration of a Low-Pressure System? A Structured-Inquiry (Very Teacher-Centered) Activity

For the Teacher:

Instruct the students that they will observe the formation and dissipation of a model low-pressure system, such as a hurricane or cyclone, by completing the following activity. Provide students with access to the materials described below. Caution students about safety procedures for handling the burner and hot water. Make sure they are wearing the safety goggles and heat-resistant gloves.

Objectives for Student

Conceptual Theme: To build a basic understanding of the relationship between heat (indicated by temperature) and a model low-pressure system

(cyclone), as defined by the “cloud” formation in the TIB/CIB device, by examining differences in the duration of clouds at varying temperatures.

Content: Establishing additional basic information about the formation of clouds in a model cyclone and how the availability of heat (indicated by temperature) affects formation and duration of the cyclone.

Skills: The focus is on observation, data collecting, presentation of data, analysis of data, making valid conclusions and communicating the outcomes.

Scientific Habits of Mind: The importance of careful observations, respect for data, respect for logic and the need to follow safety procedures.

Materials

TIB/CIB device

Metal pan for bottom of TIB/CIB

500-ml heat-resistant beaker

Enough tap water to accommodate trials at 500 ml per trial

Beaker tongs for handling a hot beaker filled with water

Electric hot plate

Non-mercury thermometer

Heat-protective gloves

Safety glasses



Procedure for Conducting the Activity

Caution the students about safety procedures in handling the burner and the hot water. Make sure they are wearing the safety goggles and heat-resistant gloves.

Trial # 1 (100 °C)

1. Place the TIB/CIB device on a solid flat surface and away from all books and other flammable materials.
2. Open the door of the TIB/CIB and center the metal container inside at the bottom. Place the hot plate on a solid surface near the TIB/CIB device.
3. Put on your safety glasses and gloves.
4. Pour 500 ml of water in the heat-resistant beaker and place it on the hot plate.
5. Turn on the hot plate and allow the water to come to a boil (100 °C). Once the water has come to a boil, use the beaker tongs and carefully lift the beaker and pour the hot water into the metal pan at the bottom of the TIB/CIB device.
6. Quickly close the door and make careful observations of the activity in the TIB/CIB device until you can no longer see the rising “cloud.” Record the duration of the rising cloud.

Trial # 1 can be repeated three or four times and the cloud duration noted, averaged and graphed to illustrate the results.

Trial #2 (90 °C)

1. Repeat steps one through four of trial #1. Turn on the hot plate and allow the water to reach a temperature of 90 °C.
2. Once the water has reached a temperature of 90 °C, use the beaker tongs and carefully lift the beaker and pour the hot water into the metal pan at the bottom of the TIB/CIB device.
3. Quickly close the door and make careful observations of what happens inside the TIB/CIB device until you can no longer see the rising “cloud.”
4. Record the results of the duration of the rising cloud.

Trial #2 can be repeated three or four times and the duration noted, averaged and graphed to illustrate the results.

Trial # 3 (60 °C)

1. Repeat steps one through four of trial #1. Turn on the hot plate and allow the water to reach a temperature of 60 °C.
2. Once the water has reached a temperature of 60 °C, use the beaker tongs and carefully lift the beaker and pour the hot water into the metal pan at the bottom of the TIB/CIB.
3. Quickly close the door and make careful observations of what happens inside the TIB/CIB device until you can no longer see the rising “cloud.”
4. Record the results of the duration of the rising cloud.

Trial #3 can be repeated three or four times and the duration noted, averaged and graphed to illustrate the results.

Examining Results

The purpose of this activity is to facilitate the learning in a concrete way about how the differences in heat (indicated by temperature) can affect the duration of the model cyclone.

How students examine the results will depend upon the number of tests conducted at the three different trial levels. If they conduct more than one test at each of the three trial levels, they can average the results for each trial and compare the three trials graphically.

Conclusion

After conducting this activity, what major conclusion did you draw regarding the relationship between temperature and the duration of the low pressure system as illustrated by cloud formation and its dissipation?

If the students were careful in both observing and recording their observations of the duration, it is very likely that the duration of the cyclone as depicted by the persistence of the model “cloud” will be longer for the higher water temperature and shorter for the lower water temperature. However, the students should be encouraged to use the data to draw conclusions. This helps to reinforce the scientific habits of mind “respect for data.” The results that vary from expectations can produce some important discussion and provide opportunities for new insights into an investigation. In this structured-inquiry activity, the learner was not sure about the outcome until the activity had been conducted. This developmental approach is beginning to shift responsibility for the learning to the learner and will be shifted more in the guided and open inquiry.

Going Further

How could you better validate the important relationship between heat (temperature) and the duration of the cyclone?

With increasing numbers of tests at the three trial levels, the more confident the experimenter should be in the average results obtained. Therefore, the learner should be encouraged to repeat a series of these tests at the different trial levels.

Challenge

Think of a series of other activities that you could perform to develop more evidence of the important relationships of heat and duration of the model cyclone.

Different conditions of the water (salt water, distilled water and so forth) could be tested with several trials at each trial level and compare the results.

Background for the Teacher

It is important to realize that the formation of tornadoes is considerably different, in that the cloud is predominantly composed of dust and debris rather than condensed water vapor.



Is There a Relationship Between Surface Heating and the Duration of a Low-Pressure System Based Upon Different Amounts of Water?

A Guided-Inquiry (Learner-Centered) Activity

For the Teacher

Purpose

Instruct the students that *they* are responsible for designing the procedure to investigate whether the amount of water affects the duration of the model low-pressure system. This is accomplished by observing the formation and dissipation of a model low-pressure system.

Provide the students with access to the materials described below. Caution the students about safety procedures in handling the burner and hot water. They should be wearing safety goggles and heat-resistant gloves.

The student is challenged to design the procedure. The teacher must successfully lead the student in devising the design without divulging too many specifics. The level of the facilitating questions becomes important in this type of guided-inquiry activity. Carefully elicit from the students the important factors to be considered and discuss these in terms of design consideration.

Carrying out this activity will use materials and procedures described in the two preceding TIB/CIB activities. Students must understand, with the teacher's guidance, that the main variable in this activity will be the amount of water used. It is important to control the other factors. Each measure of water should be at the same temperature at the

Provide these Materials (students will select from this list what they need in their design)

TIB/CIB device

Metal pan for bottom of TIB/CIB

Enough tap water to accommodate trials at 500 ml per trial

500-ml heat-resistant beaker

Beaker tongs for handling a hot beaker filled with water

Electric hot plate

Non-mercury thermometer

Heat-protective gloves

Safety glasses



beginning of the experiment. It might be interesting to compare each of the temperatures of the various amounts of water when the low pressure (cloud) is no longer visible.

The learner has had very little experience in guided inquiry and his/her responsibility for taking charge of learning. Therefore, this activity provides a series of guiding questions. As the learner becomes more experienced in conducting guided and open inquiries, less emphasis should be placed on the guiding questions.

Objectives for the Learner

Conceptual Theme: To build on the basic understanding of the relationship between the amount of water (volume) and the duration of a model low-pressure system, as defined by the “cloud” formation and dissipation.

Content: Generating additional basic information about the formation of a model low-pressure system “cloud” and establishing a greater understanding of how the availability of heat (indicated by temperature and volume of water) affects formation and duration of low-pressure systems.

Skills: The focus is on experimental design that considers observation, data collecting, presentation and analysis of data, making valid conclusions, and communicating the outcomes.

Scientific Habits of Mind: The importance of careful observations, respect for data, respect for logic and the need to follow safety procedures.

A Potential Procedure for the Learner

Background

It is important to guide the learner in designing the procedure for this activity. More responsibility for learning has been shifted to the learner. Revisit the list of question types given below and decide which

are most useful in getting the learner to understand and address this task. If the learner has had the background and experience in doing confirmation-verification and structured-inquiry type of activities, he/she should be able to transfer this learning to the design of a guided-inquiry activity.

REVIEW THESE TYPES OF QUESTIONS BEFORE BEGINNING WITH STUDENTS

Inference Questions: *These questions ask students to go beyond immediately available information that asks them to find clues, examine them, and to discuss what inferences are justified.*

Interpretation Questions: *Where inference questions demand that students fill in missing information, interpretive questions propose that they understand the consequences of information or ideas.*

Transfer Questions: *Where inference and interpretation questions ask a student to go deeper, transfer questions provoke a kind of breadth of thinking, asking students to take their knowledge to new places.*

Questions about Hypotheses: *These questions are useful in making students actively aware of their expectations because they are based on what can be predicted and tested. Typically, questions based on what can be predicted and tested are thought of as belonging to sciences and other “hard” pursuits. In fact, predictive thinking matters in all domains.*

Remember!

- *Guiding the learner and not “telling” the learner is the design challenge.*
- *Bring out key points in this procedure design (some suggested guiding questions).*

These are some guiding questions that must be considered in arriving at a design based upon the challenge question given by the teacher.

Does the amount (volume) of water affect the duration of the low-pressure system? How would you know? What would confirm that volume does or doesn't affect duration?

What method will you use to determine duration?

What materials and supplies will you need to devise an appropriate design?

What variable is a critical factor to control in this activity?

What variable will be necessary to draw a valid conclusion?

How will you present your data to make it understandable to others?

Conclusion

After conducting this activity, what major conclusion did you draw regarding the relationship between the amount of water (volume) and the duration of the low pressure system as illustrated by cloud formation and its dissipation?

It is likely that the conclusion drawn will be that as the volume of water increases (temperatures remaining the same) the duration of the low pressure (cloud) will increase also. However, if this was not the result, the students should be encouraged to use the data to draw conclusions. This helps to reinforce the scientific habits of mind "respect for data." The results that vary from expectations can produce some important discussion and provide opportunities for new insights into an investigation. This developmental approach shifts responsibility for the learning to the learner and will be shifted more in the open-inquiry type.

Going Further

How could you validate the important relationship between heat (temperature) and the duration of the low-pressure phenomena?

The higher the number of trials conducted at the three trial levels, the more confident the experimenter should be in the averaged results obtained. Therefore, the learner should be encouraged to repeat a series of these trials at the different trial levels.

Challenge

Think of other activities that you could perform to develop more evidence of the important relationships of heat and low-pressure system formation.

There are a variety of activities that could be devised, such as comparing different amounts of water at the same temperature and comparing the duration; comparing the same amount of water at different temperatures and comparing the duration; comparing different kinds of liquids such as salt water, fresh water, and distilled water using same amounts and same temperatures and comparing duration; and many others.

Develop a Testable Question and Design an Investigation That Will Provide Valid Information Regarding Factors That Affect the Formation and Duration of a Model Cloud Using the TIB/CIB Apparatus: An Open-Inquiry (Very Learner-Centered) Activity

For the Teacher

Purpose

Students should be instructed to form a hypothesis specific enough to design an experiment that can be carried out within a one-hour period. The procedure should produce data sufficient for drawing a valid conclusion.

Instruct the students that they are responsible for deriving a question specific enough so that they can carry (within about one hour) an appropriate procedure to produce data that will enable them to come to a valid conclusion regarding the question.

Provide the students with access to the materials described below and any other reasonable additional materials and equipment requested. Perhaps they can secure the additional material on their own, but under your guidance.

Caution the students about safety procedures in handling the burner and the hot water. They should wear safety goggles and heat-resistant gloves.

The student is challenged to derive a testable question and to design the procedure for resolving the question. It is a real challenge for the teacher to successfully lead the student to both the question and the design without too many specifics. The levels of the

Provide these Materials (students will select from this list what they need in their design)

TIB/CIB device
Metal pan for bottom of TIB/CIB
500-ml heat-resistant beaker
Enough tap water to accommodate trials at 500 ml per trial
Beaker tongs for handling a hot beaker with water
Electric hot plate
Non-mercury thermometer
Stopwatch or watch with second hand
Heat-protective gloves
Safety glasses



facilitating questions become very important in this type of open-inquiry activity. Carefully elicit from the students the important factors to be considered and discuss these in terms of design considerations.

Performing this activity will use materials and procedures described in the three preceding TIB/CIB activities. The student must understand, with the teacher's guidance, how to narrow the question to a point where they can specifically search and derive relevant information.

The learner has little experience in guided-inquiry and for his/her responsibility for taking charge of learning. This activity provides a series of guiding questions. As the learner becomes more experienced in carrying out guided- and open-inquiry activities, less emphasis should be placed on the guiding questions. It might be beneficial for the learners to work in groups if they have little experience with open-inquiry activities in order to take advantage of each other's helpful suggestions.

The following are examples of testable questions that students might use to design a procedure to produce data needed to draw a valid conclusion:

Does using salt water instead of distilled water affect the duration of the low-pressure cloud inside the TIB/CIB?

Does increasing the temperature of 250 ml of water to 100 °C have an equal effect on the duration of the model cloud as using 500 ml of water at 50 °C?

Does a difference in temperature outside of the TIB/CIB affect the duration of the model cloud inside the TIB/CIB? What is the lowest temperature at which a model cloud will form inside the TIB/CIB?

Does the length of the air slots in the TIB/CIB affect the length of time it takes a model cloud to form inside the TIB/CIB?

Does the width of the air slots in the TIB/CIB affect the length of time it takes a model cloud to form inside the TIB/CIB?

Does the length (or width) of the air slots in the TIB/CIB affect the duration time of the model cloud inside the TIB/CIB?

Does it make a difference in the length of time it takes a model cloud to form depending on where the outside air enters the TIB through the air slots?

YOU WILL HAVE TO REWORK THE OBJECTIVES FOR THE STUDENT IN A WAY TO EVALUATE HIS/HER EFFORTS

Conceptual Theme: *Did the question and activity add new insight into the student's understanding of change, organization, or interrelationships?*

Content: *Did the question and the activity add new insight and understanding of content knowledge of meteorology?*

Skills: *Did the question and the activity add to the skill development or enhancing basic skill development for the student?*

Scientific Habits of Mind: *Did the question and the activity illustrate means by which the scientific habits of mind were further nurtured on the part of the learner?*

Guiding The Learner In Developing a Testable Question and In the Design Challenge

*Outline of key points in this procedure design
(some suggested guiding questions):*

*For example, does doubling the temperature
(100 °C versus 50 °C) of half the volume of water
(200 ml versus 400 ml) result in providing equal
durations of the model cloud inside the TIB/CIB?
How would you know? What kind of design and data
would help you resolve this question?*

What method will you use to determine duration?

*What materials and supplies will you need for
an appropriate design?*

What variable(s) is critical to control in this activity?

*What variable will give the data necessary to
draw a valid conclusion?*

*How will you present your data to make it
understandable to others?*

*These are some guiding questions that you must
consider in arriving at a design based upon the
challenge questions that you have developed.*

Examining Results

*As the teacher of this open inquiry you must use
your knowledge, background and experience from
the series of previous activities to help the student
draw an appropriate and valid conclusion from the
activity.*

*It is time to put this experience and knowledge to
work performing some weather predictions using
a weather station and observations involving
cloud types.*

*Before that happens, there is a challenge for both
teacher and learner in a type of practical test to see
how well the levels of inquiry have been mastered.*

This Page for Notes